V. "Results deduced from the Measures of Terrestrial Magnetic Force in the Horizontal Plane, at the Royal Observatory, Greenwich, from 1841 to 1876." By Sir G. B. AIRY, K.C.B., F.R.S., late Astronomer Royal. Received June 24, 1885.

(Abstract.)

In offering to the Royal Society some results deduced from the systems of magnetic observation and magnetic self-registration established several years since at the Royal Observatory, Greenwich, during a portion of the time in which I presided over that institution, I think it desirable to premise a short statement on the origin of the Magnetic Department of the Royal Observatory, and on the successive steps in its constitution.

It appears to have been recognised many years ago, that magnetic determinations would form a proper part of the business of the Royal Observatory. When I commenced residence at the Royal Observatory, at the end of 1835, I found in the garden a small wooden building, evidently intended for the examination of compasses, perhaps of the size of those used in the Royal Navy. But the locality was inconvenient, and the structure was totally unfit for any delicate magnetic purpose; for instance, the balance-weights of the sliding windows were of iron. For some preliminary experiments a small observatory was borrowed from Captain Fitzroy, but no real progress was made in magnetism.

In the beginning of 1836, a scheme for the erection of a Magnetical Observatory was brought before the Board of Visitors. The Board approved the plan, and recommended it favourably to the Admiralty. The Government Department superintending the Park gave their consent to an extension of the grounds of the Observatory, and the ground was inclosed in 1837. The Magnetic Observatory was built, from my plans, in the spring of 1838. Since that time, no alteration has been made in the building, except in 1864, when the ground below the east, west, and south arms, was excavated, in order to obtain positions for the three fundamental instruments in which the severity of the temperature-changes would be much diminished. Small accidental interruptions of observations occurred in 1847, January, and 1861, July.

The interest taken in the subject of terrestrial magnetism in the first half of this century was occasioned principally by the enterprise of Gauss and other German philosophers. Magnets were, therefore, established at the Royal Observatory, furnished with apparatus adapted to eye observations corresponding to those of Gauss, and some

observations were made in concert with the Germans. The observations to the end of 1847 with these instruments were made entirely by eye; the instruments (magnets 2 feet in length) being furnished with small plane reflectors, to which telescopes were directed, and by which fixed marks were observed. The observations were made at every two hours, day and night; proper precautions were taken for assurance of the general accuracy of the times of observation; and I do not doubt that the results interpreted from these observations are each as good as those derived from the succeeding system; though the intervals of two hours were longer than I could wish. But the labour was great, and (as measured by the interruption of assistants' work) was expensive.

The idea of self-registration by photography of the movements of the intruments (an idea little entertained before that time) then suggested itself; and, at the Cambridge Meeting of the British Association in 1845, it was proposed for consideration of the Council of that body, that the Government should be requested to promote, by offer of a pecuniary reward, the construction of a photographic self-registering instrument. This proposal was adopted by the Council; letters were addressed by Sir John Herschel, President of the Association, to Her Majesty's Treasury, and by myself to the Admiralty; and, finally, the assistance of Dr. Charles Brooke was secured, for forming an efficient apparatus, and making the necessary chemical arrangements adapted to our wants.

I do not propose here to describe the photographic recording apparatus. Allusions to the construction will be found in the Introductions to the Greenwich Observations for successive years, and especially, and in great detail, in the introduction to the volume for 1847. The only alteration that was made in it for several years is the following. Mr. Brooke had conceived that advantage would be gained by making the recording barrel to revolve in twelve hours. But this caused a doubling of the curves traced on the photographic paper which is wrapped upon the barrel; and the inconvenience produced by this doubling was soon found to be so great that I thought it necessary to alter the clock-work so as to produce a revolution of the barrel in twenty-four hours. The records of the change of western declination from the north, and of the change of horizontal force, are made on the same barrel; and by alterations, first suggested by myself about 1881, and carried out by the present Astronomer Royal (then Chief Assistant), the two curves are now so traced that the simultaneous records of the two instruments at all times are in close juxtaposition.

While the observations were made by eye, at every two hours, the means of the two-hourly readings were adopted as base for the day, and the excess of each two-hourly reading above the mean was adopted

as "magnetic inequality" of that ordinate for that hour; producing twelve measures of "inequality" for each day. When the photographic system was introduced, the elevation of a pencil curve drawn by eye so as to smooth down the irregularities of the photographic trace above a photographic base was measured for every hour, producing twenty-four measures of "inequality."

In the instances of excessive and rapid disturbances of the magnets during magnetic storms, no measures of ordinates were taken for the present purposes.

Thus the daily measures at each hour or two hours were obtained.

The next step was to collect for each month all the daily measures on corresponding hours through each month, and to take their mean. These are the measures for the hours which are actually treated in the present memoir. By combining (for each month) the inequality of magnetic horizontal force at every two hours or each hour, as abscissa, with the inequality of magnetic declination (on the same scale of measure) at the same two hours or hour, as ordinate, points were defined in every monthly curve representing completely the mean diurnal changes of magnetism for each month. On the recommendation of the Board of Visitors of the Royal Observatory, reduced photographic copies of these curves were prepared by the Astronomer Royal for publication with the volume of Greenwich Observations for 1884.

The number, and the character, of the curves produced uninterruptedly on this plan, and the circumstance that they are intended for publication in the Greenwich Observations, appear to render them unfit for dissemination in the Royal Society's Transactions. I have, therefore, decided on the following course. With the permission of the Astronomer Royal, I have adopted the three years 1863, 1864, 1865, for partial exhibition of results. (Any other years would have answered equally well, for general exhibition.) For each of these years I have attached to this paper the curves for the months January, April, July, October, which suffice for showing generally the characteristic changes of magnetism for the several months. But some general account may be given, for which this is perhaps a suitable place.

The form of the curves, and the position of the points on them corresponding to hours of solar time, leave no doubt that the diurnal inequality is due mainly—and, as far as I can judge, entirely—to the radiant heat of the sun; and, it would seem, not to the sun's heat on the earth generally, but to its heat on parts of the earth not very distant from the magnets. In the hot months of the year, the curve, though far from circular, surrounds the central point in a form which, as viewed from that central point, never crosses itself; and is, roughly speaking, usually symmetrical with regard to E. and W.

But in the cold months, the space included in the curve is much smaller in many cases, probably not more than one-sixth of what it is in the summer months; and the curve often crosses itself in the most bizarre fashion with irregular loops stretching out, three crossings in one curve occurring very frequently. In the summer months there is a certain degree of symmetry; but here is, constantly, a preponderance on the west side, which leads me to imagine that the magnetic effect of the radiant heat upon the sea is considerably greater than the effect on the land.

To obtain some numerical basis for a report, which though exceedingly imperfect may convey some ideas on this wonderful subject, I have adopted the following course. I have confined myself to the months of June and July as probably the two hottest, and the months of December and January as probably the two coldest. For each of the curves applying to these months, I have laid down a system of rectangular co-ordinates, corresponding to the Greenwich meridian and to the line at right angles to the meridian (or the geographical E. and W.). The extreme north ordinate and the extreme south ordinate are measured, and their sum is taken, and interpreted by a scale of measure formed in accordance with the theory of the intruments; and this interpreted sum forms the "Range of Meridian Force" in terms of the whole Meridian Force. In the same manner, the "Range of Transversal Force" is measured. As the time of each of the two-hourly or hourly records is marked on the curve, there is no difficulty in fixing approximately on the solar times corresponding to the extreme N. and S. values, and the extreme E. and W. values, mentioned above. These are all the elements of the magnetic record which are described in the subjoined table.

The changes in the monthly records are very remarkable. They leave no doubt in my mind that the diurnal magnetic changes are produced by the sun. But I cannot account for every change that takes place in the course of a day; nor can I undertake to say whether we can found, on these, the theory that general terrestrial magnetism is a part of solar radiation, perhaps sometimes acting through or sometimes impeded by the masses of land and sea on which that radiation acts.

Still I think that a considerable step is made by the establishment of a connexion between terrestrial magnetism (on one hand), and the radiation, or, at least, the visibility of the sun (on the other hand).